September 2009
IYA Discovery Guide

This Month's Theme:

Planets and Moons

Featured Activity:

Pocket Solar System

Featured Observing Object:

Jupiter

The International Year of Astronomy is a global celebration of astronomy and its contributions to society and culture, highlighted by the 400th anniversary of the first use of an astronomical telescope by Galileo Galilei.
Join us as we look up! http://astronomy2009.us

The Astronomical Society of the Pacific increases the understanding and appreciation of astronomy by engaging scientists, educators, enthusiasts and the public to advance science and science literacy.
www.astrosociety.org

September's Topic:
Planets and Moons


Credit NASA

Galileo's telescopic discoveries shook the foundations of the cosmology handed down from the ancients. He observed sunspots, the rugged surface of the Moon, and perhaps most profoundly, bright Jupiter and what appeared to be four small companion bodies (right). He noticed that these four objects were lined up and that they changed positions over time. Galileo realized that the four satellites were orbiting Jupiter, directly contradicting the older idea that Earth is the center of motion for all heavenly bodies. You can see this bright planet in the night sky this month. See the Finder Chart in this Guide to find out where to look for it.

Of course, we now know that the planets of the Solar System orbit the Sun, not Earth, and all the planets except for the two closest to the Sun have at least one moon to keep them company. In fact, there are 144 known planetary moons, with at least 21 more awaiting official recognition. Telescopes have improved considerably since Galileo's time, growing larger and more sophisticated. Because Earth's atmosphere interferes with observations, NASA sent telescopes into orbit around the Earth, including the Hubble Space Telescope and later the infrared Spitzer Space Telescope. NASA increased our observational powers with spacecraft sent to all eight planets as well as to many moons, asteroids, and comets. Galileo would be quite surprised to learn that humans have explored and walked upon Earth's Moon, even bringing back moon rocks for study.

What we know about the Solar System has increased dramatically in just the last few decades. One of the spacecraft that changed the way we look at the planets and moons was named after Galileo. The Galileo spacecraft was the first to fly past an asteroid and the first to discover a moon of an asteroid. It provided direct observations of a comet colliding with a planet. It was the first to measure Jupiter's atmosphere with a descent probe and the first to conduct long-term observations of the Jovian system from orbit. The moons of Jupiter reflect the great diversity of moons throughout the solar system - Io is the most volcanically active body in the entire solar system, and evidence supports the presence of a hidden subsurface ocean of water on Europa.

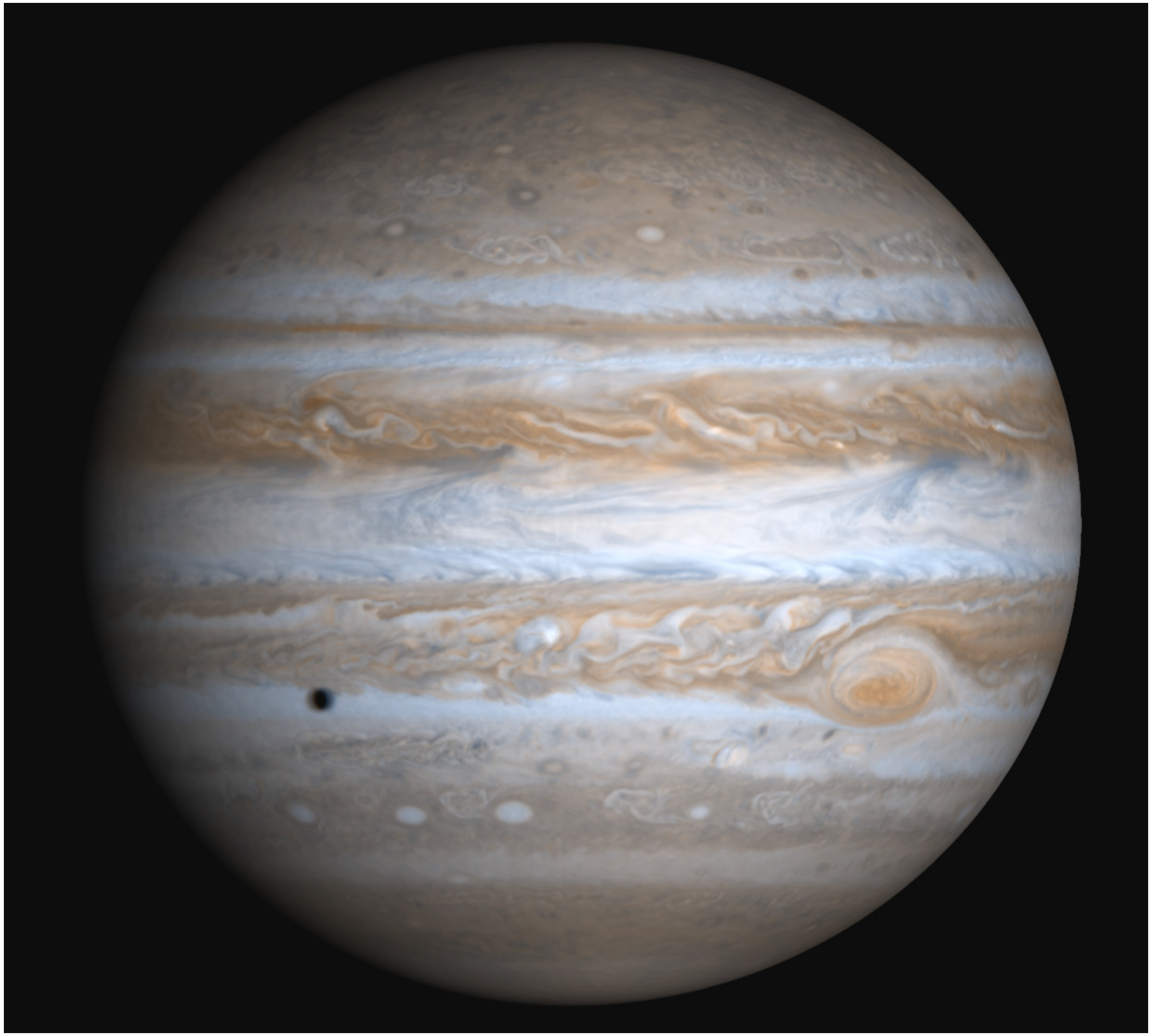
Our journey of discovery has just begun. Cassini-Huygens, in orbit at Saturn, is imaging the rings and moons and unveiling methane lakes below the clouds of the moon Titan. The Mars Exploration Rovers and the Phoenix Lander have researched the terrain and soil of Mars. And there will likely be more surprises waiting. The Messenger spacecraft passes by Mercury this month and will settle into orbit in 2011 to conduct extensive studies of this innermost planet. The LRO and LCROSS missions will map the surface and look for water ice on our own Moon. NASA spacecraft travel even to the most distant places — use the attached activity to find out why it will take the New Horizons mission a decade to reach the outer edge of our Solar System.

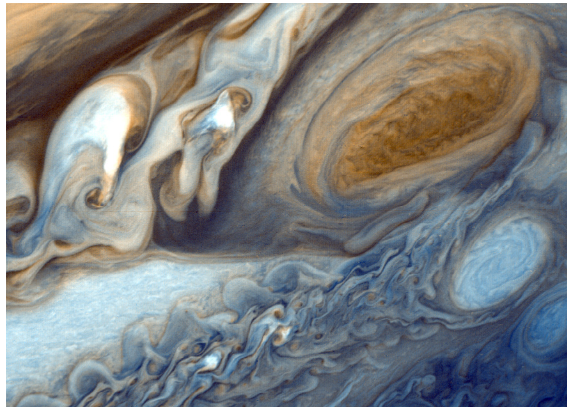
Learn more about Planets and Moons from NASA.
Find more activities featured during IYA 2009.
See what else is planned for the International Year of Astronomy.

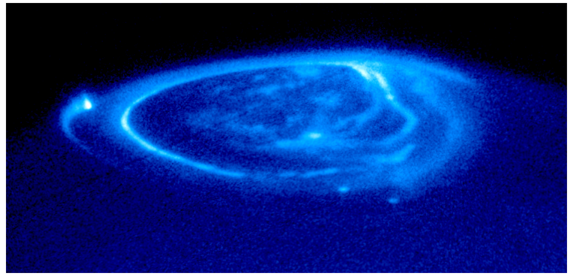
THE UNIVERSE YOURS TO DISCOVER INTERNATIONAL YEAR OF ASTRONOMY 2009

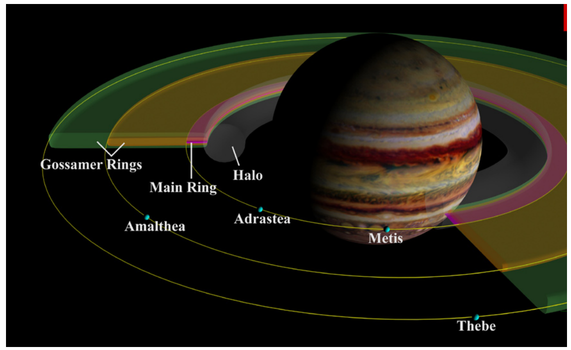
National Aeronautics and Space Administration
www.nasa.gov

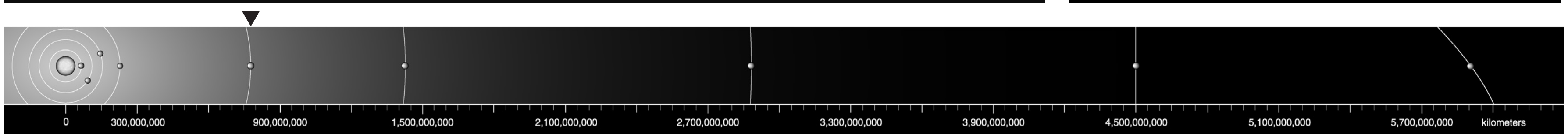
Jupiter











National Aeronautics and Space Administration
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Jupiter

The most massive planet in our solar system, with four planet-sized moons and many smaller moons, Jupiter forms a kind of miniature solar system. Jupiter resembles a star in composition. In fact, if it had been about eighty times more massive, it would have become a star rather than a planet.

On January 7, 1610, using his primitive telescope, astronomer Galileo Galilei saw four small “stars” near Jupiter. He had discovered Jupiter’s four largest moons, now called Io, Europa, Ganymede, and Callisto. Collectively, these four moons are known today as the Galilean satellites.

Galileo would be astonished at what we have learned about Jupiter and its moons in the past 30 years. Io is the most volcanically active body in our solar system. Ganymede is the largest planetary moon and is the only moon in the solar system known to have its own magnetic field. A liquid ocean may lie beneath the frozen crust of Europa. Icy oceans may also lie deep beneath the crusts of Callisto and Ganymede. In 2003 alone, astronomers discovered 23 new moons orbiting the giant planet, giving Jupiter a total moon count of 62 — the most in the solar system. The numerous small outer moons may be asteroids captured by the giant planet’s gravity.

Jupiter’s appearance is a tapestry of beautiful colors and atmospheric features. Most visible clouds are composed of ammonia. Water exists deep below and can sometimes be seen through clear spots in the clouds. The planet’s “stripes” are dark belts and light zones created by strong east–west winds in Jupiter’s upper atmosphere. Within these belts and zones are storm systems that have raged for years. The Great Red Spot, a giant spinning storm, has been observed for more than 300 years.

The composition of Jupiter’s atmosphere is similar to that of the Sun — mostly hydrogen and helium. Deep in the atmosphere, the pressure and temperature increase, compressing the hydrogen gas into a liquid. At depths about a third of the way down, the hydrogen becomes metallic and electrically conducting. In this metallic layer, Jupiter’s powerful magnetic field is generated by electrical currents driven by Jupiter’s fast rotation. At the center, the immense pressure may support a solid core of ice–rock about the size of Earth.

Jupiter’s enormous magnetic field is nearly 20,000 times as powerful as Earth’s. Trapped within Jupiter’s magnetosphere (the area in which magnetic field lines encircle the planet from pole to pole) are swarms of charged particles. Jupiter’s rings and moons are embedded in an intense radiation belt of electrons and ions trapped in the magnetic field. The jovian magnetosphere, comprising these particles and fields, balloons 1 to 3 million kilometers (600,000 to 2 million miles) toward the Sun and tapers into a windsock-shaped tail extending more than 1 billion kilometers (600 million miles) behind Jupiter as far as Saturn’s orbit.

Discovered in 1979 by NASA’s Voyager 1 spacecraft, Jupiter’s rings were a surprise: a flattened main ring and an inner cloud-like ring, called the halo, are both composed of small, dark particles. A third ring, known as the gossamer ring because of its transparency, is actually three rings of microscopic debris from three small moons: Amalthea, Thebe, and Adrastea. Jupiter’s ring system may be formed by dust kicked up as interplanetary meteoroids smash into the giant planet’s four small inner moons. The main ring probably comes from the moon Metis. Jupiter’s rings are only visible when backlit by the Sun.

In December 1995, NASA’s Galileo spacecraft dropped a probe into Jupiter’s atmosphere, which collected the first direct measurements of Jupiter’s atmosphere. Following the release of the probe, the Galileo spacecraft began a multiyear study of Jupiter and the largest moons. As Galileo began its 29th orbit, the Cassini–Huygens spacecraft was nearing Jupiter for a gravity-assist maneuver on the way to Saturn. The two spacecraft made simultaneous observations of the magnetosphere, solar wind, rings, and Jupiter’s auroras.

FAST FACTS

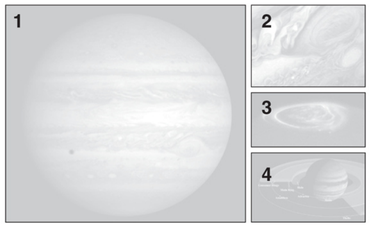
Namesake	King of the Roman gods
Mean Distance from the Sun	778.41 million km (483.68 million mi)
Orbit Period	11.8565 Earth years (4,330.6 Earth days)
Orbit Eccentricity (Circular Orbit = 0)	0.04839
Orbit Inclination to Ecliptic	1.305 deg
Inclination of Equator to Orbit	3.12 deg
Rotation Period	9.92 hr
Equatorial Radius	71,492 km (44,423 mi)
Mass	317.82 of Earth’s
Density	1.33 g/cm^3
Gravity	20.87 m/sec^2 (68.48 ft/sec^2)
Atmosphere Primary Components	hydrogen, helium
Effective Temperature	–148 deg C (–234 deg F)
Known Moons*	62
Rings	1 (three major components)

*As of November 2005.

SIGNIFICANT DATES

1610 — Galileo Galilei makes the first detailed observations of Jupiter using a telescope.
1973 — Pioneer 10 becomes the first spacecraft to cross the asteroid belt and fly past Jupiter.
1979 — Voyager 1 and 2 discover Jupiter’s faint rings, several new moons, and volcanic activity on Io’s surface.
1994 — Astronomers watch pieces of comet Shoemaker–Levy 9 collide with Jupiter.
1995–2003 — The Galileo spacecraft conducts extended observations of Jupiter and its moons and rings.

ABOUT THE IMAGES



1 A detailed, true-color image of Jupiter taken by the Cassini spacecraft. The Galilean moon Europa casts a shadow on the planet.

2 A Voyager 1 image of Jupiter’s Great Red Spot.

3 An image of Jupiter’s aurora, a sign of the interaction between Jupiter’s magnetic field and energy from the Sun.

4 A schematic of the components of Jupiter’s ring system.

FOR MORE INFORMATION

solarsystem.nasa.gov/planets/profile.cfm?Object=Jupiter

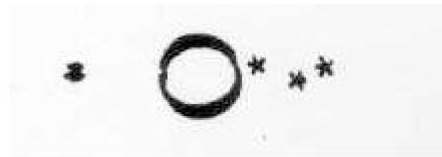
LG-2005-12-573-HQ — JPL 400-1253L 12/05

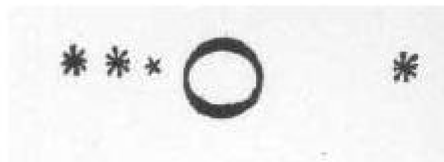
September 2009 Featured Observing Object:

Jupiter
Finder Chart

For information about Jupiter:
http://solarsystem.nasa.gov/planets/profile.cfm?Object=Jupiter

To view: unaided eyes, binoculars, or telescope

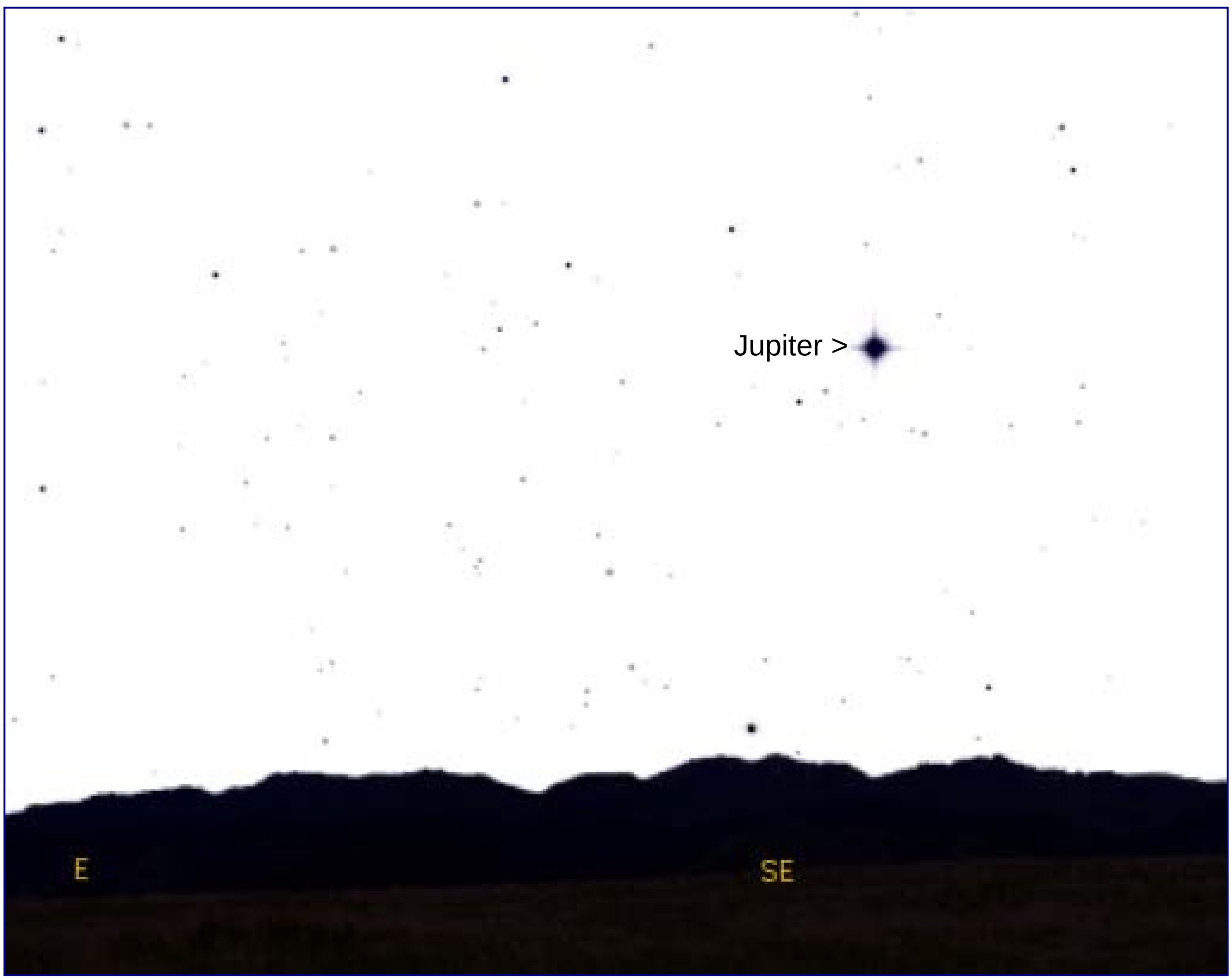




Examples of Galileo's drawings of Jupiter and its moons.

During September this year, look for Jupiter above the southeastern to eastern horizon after sunset. The brightest star-like object you see in that direction is the planet Jupiter.

Look at Jupiter through the telescope and see what Galileo saw 400 years ago: Jupiter has moons. You might see up to four moons. Look again an hour later and you might notice that the moons have moved positions. Galileo noticed this too and made drawings of these changes (see illustrations to the right).

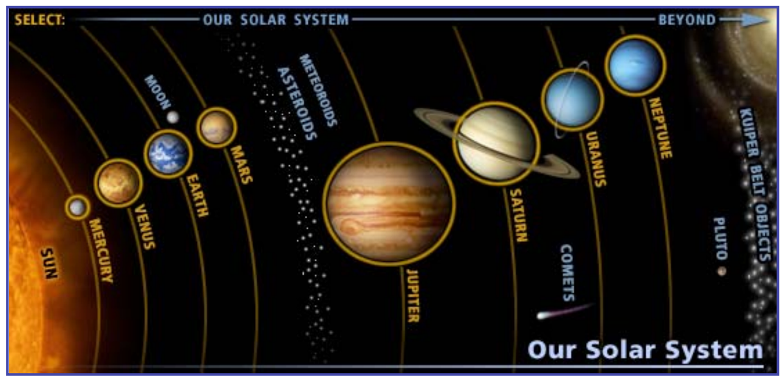


Pocket Solar System

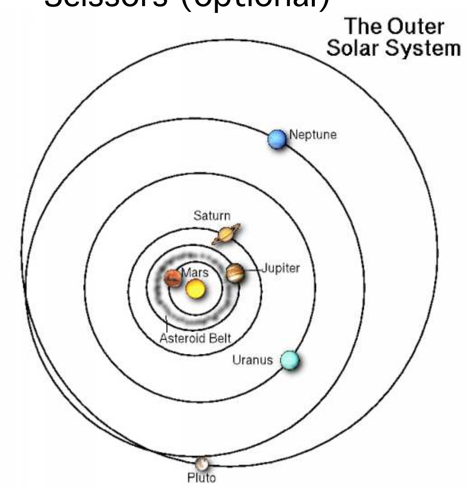
Make a Scale Model of the Distances in our Solar System

About the Activity
Using a strip of paper, construct a quick scale model of the distances between the orbits of the planets, the Asteroid Belt, and Pluto as part of the Kuiper Belt.

Topics Covered
- Scaled distances of orbits in the Solar System
- Types of objects in the Solar System
- Usefulness of models



Materials Needed
- Pencils
- Paper tape at least 2" wide (from a cash register)
- Scissors (optional)



Credit: National Schools' Observatory

Participants
This activity is appropriate for families, the general public, and school groups ages 7 and up. Any number of visitors may participate.

Location and Timing
This activity can be before a star party, in a classroom, or in a general presentation.
Warning: wind can present a challenge.

Included in This Activity
Detailed Activity Description
Helpful Hints
Background Information

Additional astronomy activities can be found here: http://nightsky.jpl.nasa.gov

Detailed Activity Description

Pocket Solar System

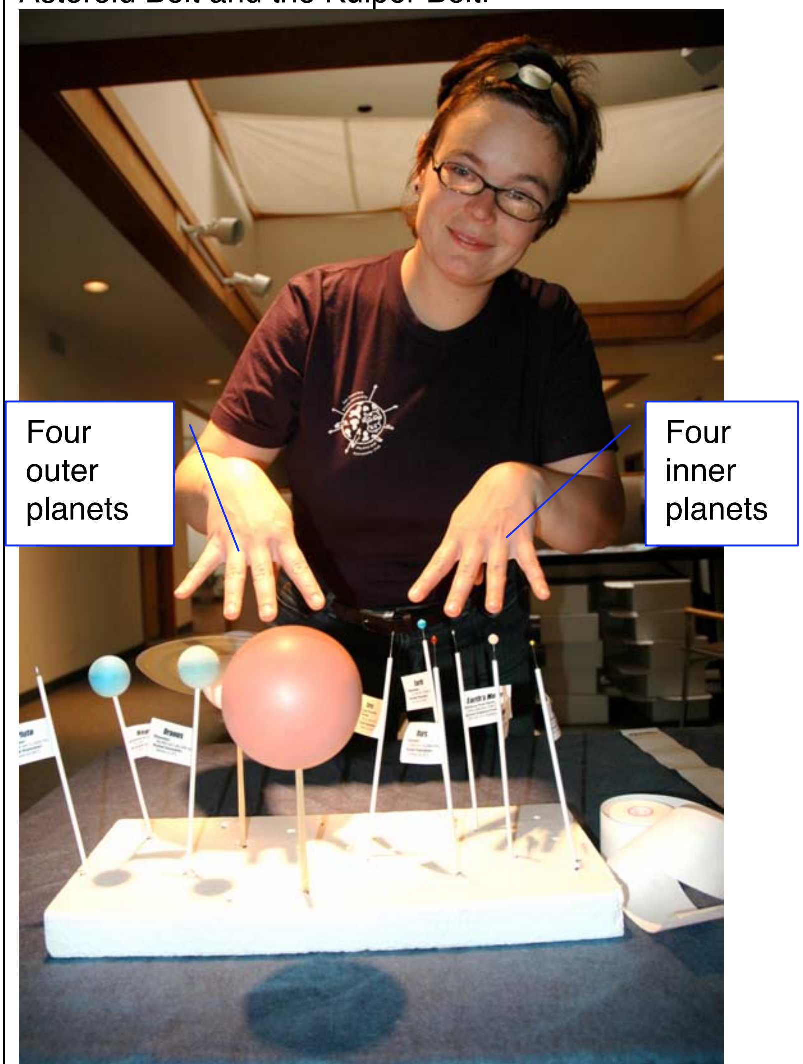
The order of the worlds of the Solar System going out from the Sun and their average distances are:

Object	Avg Distance in kilometers	Avg Distance in miles	Avg Distance in AU*
Mercury	58 million	36 million	0.4
Venus	108 million	67 million	0.7
Earth	150 million	93 million	1
Mars	228 million	142 million	1.5
Ceres ** (representing the Asteroid Belt)	414 million	257 million	2.6
Jupiter	778 million	484 million	5.2
Saturn	1,427 million	887 million	9.5
Uranus	2,870 million	1,784 million	19
Neptune	4,498 million	2,795 million	30
Pluto ** (representing the Kuiper Belt)	5,906 million	3,670 million	40 (range is 30 – 50 AUs)

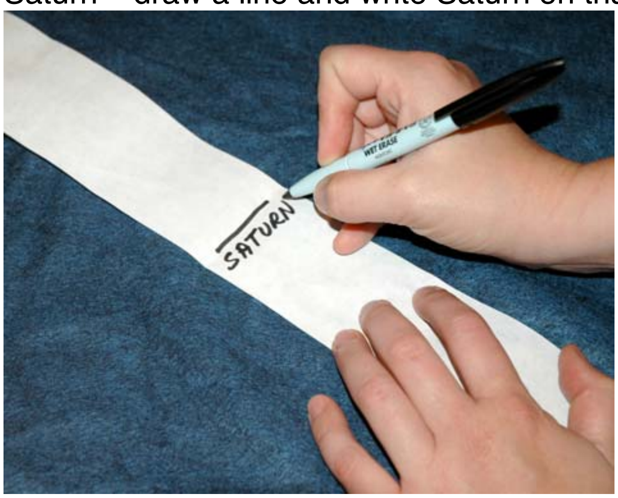
*AU stands for "astronomical unit"and is defined as the average distance between the Sun and the Earth (about 93 million miles or 150 million kilometers).

**The International Astronomical Union (IAU), the organization in charge of naming celestial objects, classified these objects as "dwarf planets" in 2006.

Leader's Role	Participants' Role (Anticipated)
Objective: Building scale models of the Solar System is a challenge because of the vast distances and huge size differences involved. This is a simple little model to give you an overview of the *distances* between the orbits of the planets and other objects in our Solar System. • Provide a quick, easy-to-make and remember scale of the approx distances of the planet's orbits and orbital distance of other realms (asteroids, Kuiper Belt) from the Sun. • Introduce basic "realms" of the Solar System: the Sun at the center, the four inner terrestrial planets separated from the four outer gas giants by the asteroid belt, and all of it surrounded by Kuiper Belt. • Can be referred to and used in other activities.	

Leader's Role	**Participants' Role (Anticipated)**
To say: Let's make a Solar System you can keep in your pocket! *To do:* First, establish with your audience the order of the planets. This provides a baseline to work from. List them on a sheet of paper, use the "Solar System to Scale" handout, the lithographs, or the 3-D models of the planets. Be sure to include the Asteroid Belt and the Kuiper Belt.  Pointing to the four inner rocky planets and the four outer gas giant planets.	Yeah!

Leader's Role	**Participants' Role (Anticipated)**
To say: Pull off a strip of register tape about the length of the height of your body – that's about fingertip to fingertip. We're going to make a model that shows the average distances of various orbits from the Sun. Fold over (or cut) the ends so they are straight. Label one end "Sun" and the other end "Pluto/Kuiper Belt." That will be our baseline – the average distance between the Sun and Pluto's orbit. Next, fold the tape in half, crease it, open it up again and place a mark at the half-way point. Let's look at the list of planets in the Solar System. Which planet's orbit do you suppose is half-way between the Sun and the average distance of Pluto's orbit? Let me give you a hint.	Follows directions. Jupiter! Saturn!
Presentation Tip: You'll need to be careful about using this hint. It depends on your audience. Some people may be offended. It is quite popular with children, however. Alternatively, just have them guess from the list of planets. "Uranus" is often incorrectly pronounced as "yur-AY-nus." Correct pronunciation is "YUR-uh-nus." For more information: http://www.nineplanets.org/uranus.html	
To do: Turn around so your back is to the audience. Hold the Pluto end of the tape at your head so the tape falls down your back to the floor. *To say:* If you hold the Pluto end at your head and the Sun at your feet, what body part is halfway between? Right. Bet you'll never again forget which planet is halfway between the Sun and the average distance of Pluto.	Uranus!

Leader's Role	Participants' Role (Anticipated)
To say: Draw a line on the fold and write "Uranus." Re-fold the tape in half, then in half again so you have quarters. Then unfold it. Now you have the tape divided into quarters with the Sun at one end, Pluto's orbit on the other, and Uranus' orbit in the middle. Label the fold closer to Pluto as "Neptune" and the fold closer to the Sun as – OK everyone guess.	Jupiter? Mars?
Saturn – draw a line and write Saturn on that orbit.  Here's an easy way to remember the order of the orbits of these three planets. There's a Sun at the center of the Solar System. *To do:* Point to the Sun end of the tape. *To Say:* And there's a "SUN" in the outer planets: (S)aturn (U)ranus (N)eptune S-U-N!	

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td colspan="2">Presentation Tip:
Encourage your visitors to draw a line along the fold marking the orbit and write the name of the planet along that line. This will help keep the writing small enough so the names are less likely to overlap orbits for other planets, especially for the inner planets.

An alternative, to speed things up when visitors may not know how to spell all the names of the planets, is to just have them write the initial letter of the planet on each orbit line.


</td></tr>
<tr><td><u>To Say:</u>

You’ve mapped out 3/4 of the Solar System and you still don’t have all the gas giants. Which gas giant is missing?

So we have to fit everything else in that last quarter between the Sun and Saturn! Let’s keep going.

Place the Sun end of the tape at Saturn’s orbit and crease the tape at the fold. What’s the next planet in?
Label that fold.

Fold the Sun out to meet Jupiter’s orbit. This is a little tricky. What structure is inside Jupiter’s orbit?

Right, the Asteroid Belt. Label that.

How many more planets do we need to mark?

At this point, things start getting a little crowded and folding is tough to get precise distances. Fold the Sun to the Asteroid Belt mark and crease it. Next planet in?

Right – Mars. Label that.</td><td>Jupiter!

Jupiter.

Asteroids?

Four!

Mars!</td></tr>
</table>

Leader's Role	**Participants' Role (Anticipated)**
How many more planet orbits do we need to place? Yes, three. Fold the Sun up to meet the orbit of Mars. Leave it folded and fold that section in half again. (See the "Schematic of the Pocket Solar System" on the next page) Unfold the tape and you should have three creases. Mark Earth on the crease nearest Mars, then Venus, then Mercury closest to the Sun. Stretch out your model and take a good look at what you've made. What surprises did you have? Now, just roll it up and put it in your pocket – the Pocket Solar System.	Three – Earth. Venus, and Mercury. Variety of comments.
Misconception Tip: Many people are unaware of how empty the outer Solar System is (there is a reason they call it space!) and how close, relatively speaking, the orbits of the inner Solar System are.	

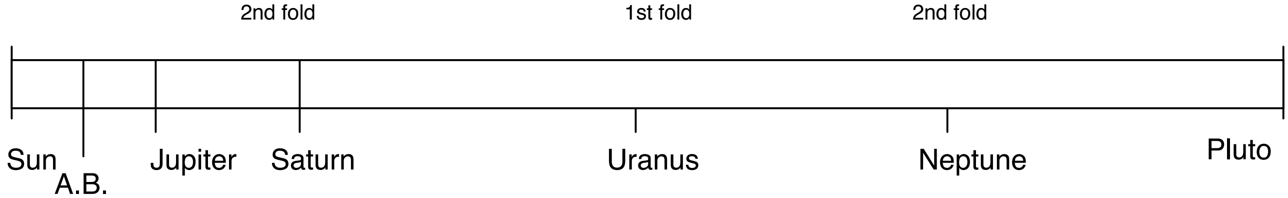
<u>Here are some questions to consider while discussing your Pocket Solar System:</u>

1. If your model is 1.5 meters long (about 5 feet), where would the nearest star be? (1.5m = 40 AUs, Proxima Centauri is 4.3 light years from the Sun, and 1 light year = 63,250 AUs)
2. How big would the Sun and planets be if your model were one and a half meters long?

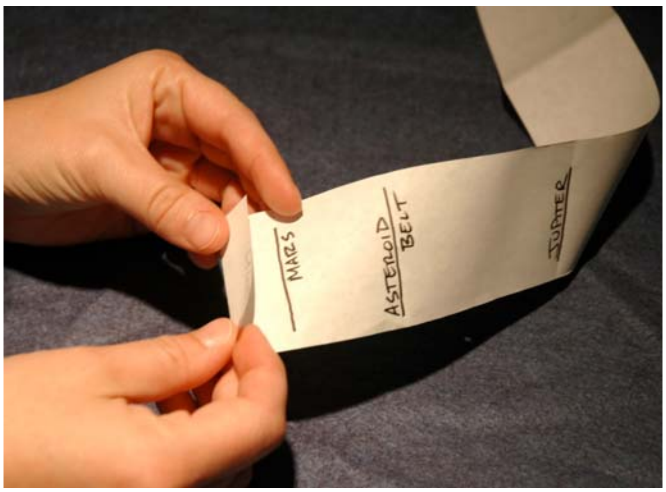
<u>Answers:</u>

1. The nearest star would be about 10 kilometers or about 6 miles away.
2. The Sun would be smaller than a grain of sand – about the size of the period at the end of this sentence. You couldn't see any of the planets without a strong magnifying glass on this scale!

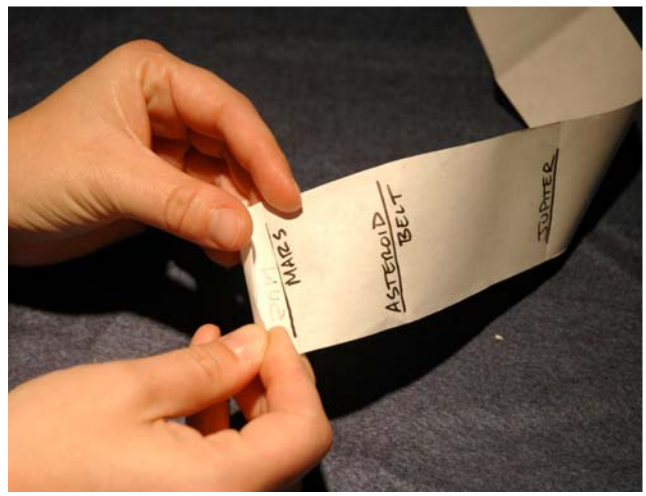
Schematic of the Pocket Solar System:



Fold Sun to Asteroid Belt, ("A.B.") mark "Mars" on fold.

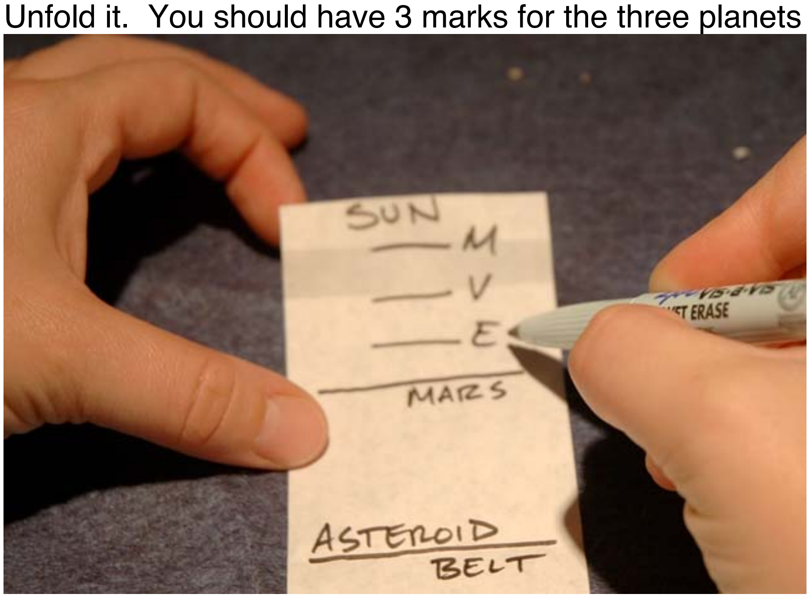


Fold Sun to Mars and leave it folded.



Then fold that section in half again.

Unfold it. You should have 3 marks for the three planets closest to the Sun.



Helpful Hints

Discussion of Models and their Usefulness

Models are useful, but their utility is always limited in some ways. It is often helpful to discuss the strengths and limitations of models with your visitors. For example, the paper tape represents the scaled distances to objects in our Solar System. What are some of its strengths as a model? How is it useful? Where does this NOT represent reality? What can't it be used for? These are questions you may want to include in your discussions with your visitors as they explore the Solar System with this model.

Common Misconceptions:

- Planets are perceived to be much larger than they really are
- The distances to the planets are perceived to be much smaller than they really are
- The orbits of the planets are perceived to be evenly spaced between the Sun and Pluto

Background Information

Website:
For additional information on the worlds of the Solar System, use NASA's Solar System Exploration website:
http://solarsystem.nasa.gov/planets/index.cfm

Website:
A useful web site for **calculating scale models of the Solar System** is available from the Exploratorium:
http://www.exploratorium.edu/ronh/solar_system/

Pocket Solar System and Bode's "Law"

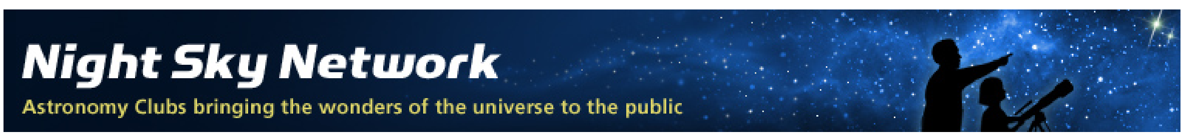
The progression followed for the positions of the orbits for the planets of our Solar System, as illustrated by the Pocket Solar System activity, is really just an interesting coincidence.

Bode's Law, also known as the Titius-Bode Law, was developed in the 1700's before the discovery of Uranus, Neptune, Pluto, or the Asteroid Belt. This "Law" is a mathematical way to describe the approximate spacing of the planets from the Sun. It is not a scientific law and does not work for all the planets of the Solar System, Neptune being a notable exception. It also does not appear to work for planetary configurations around other stars.

For more information on this "Law," try one of these websites:
http://en.wikipedia.org/wiki/Titius-Bode_law
http://milan.milanovic.org/math/english/titius/titius.html

The Night Sky Network's International Year of Astronomy (IYA) Discovery Guides are supported and sponsored by these NASA Forums and missions:

Space Telescope Science Institute's Origins Education Forum
Special Advisor: Denise Smith
NASA JPL's PlanetQuest Exoplanet Exploration Program
Special Advisor: Michael Greene
NASA Lunar CRater Observation and Sensing Satellite (LCROSS)
NASA Education Forum on the Structure and Evolution of the Universe
NASA Education Forum on Solar System Exploration
NASA Education and Public Outreach at Sonoma State University
NASA Goddard Space Flight Center Suzaku Mission E/PO Program
NASA's Kepler Discovery Mission



The Night Sky Network is a nationwide coalition of amateur astronomy clubs bringing the science, technology, and inspiration of NASA's missions to the general public.

We share our time and telescopes to provide you with unique astronomy experiences at science museums, observatories, classrooms, and under the real night sky.
http://nightsky.jpl.nasa.gov

The International Year of Astronomy (http://astronomy2009.us) aims to help citizens of the world rediscover their place in the Universe through the daytime and nighttime sky. Learn more about NASA's contributions to the International Year of Astronomy at http://astronomy2009.nasa.gov